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Taxi Gabs

Wedged next to a taxi in a crosstown traffic jam in New York City, I called out to its driver, "Traffic's really bad today, isn't it?" And he replied, "It's all in how you look at it, son. If the Russians attacked today, they'd never get past Fifth Avenue!"

John E. Gilbert
Via Reader's Digest

HIGHWAY EXPENDITURES IN ILLINOIS

by John D. Orzeske

During the past fifteen years there has been a spectacular rise in highway expenditures within Illinois. In assessing the practicability of future highway plans for various areas of the state, it is appropriate to consider the scale which these expenditures have reached; and whether they represent a continuing trend or are simply the result of a crash program to correct for deficiencies occurring from the imposition of wartime restrictions or other reasons. It is also necessary to evaluate the revenues supporting these expenditures in order to reach some conclusion regarding the longevity of the present trend.

This review is confined to expenditures and revenues of the Illinois Division of Highways. An analysis at this level is best suited for this brief examination, because the state is the major recipient of highway user funds, i.e., the motor fuel tax and vehicle registration fees. Further, state accounting data for expenditures include the distribution of federal aid grants and the allocation of user revenues to lower level governmental units.

Data concerning local revenue from vehicle and property taxes for highway purposes are not included. The amounts of these funds do, of course, vary considerably according to the needs and policies of the various communities. In most instances, however, these revenues are expended for local street improvements or as matching funds to state and federal programs. Since planning for broad areas and heavy volumes of traffic must necessarily be most concerned with expressway and arterial street functions, the trend in the financial operations of the state is related closely to the viability of these plans.

As FIGURE 1 demonstrates, after a twenty-five year period of gradually increasing expenditures, the immediate postwar period saw a drastic and continuing rise in expenditures by the Illinois Division of Highways reaching a high point of 444 million dollars in 1960.

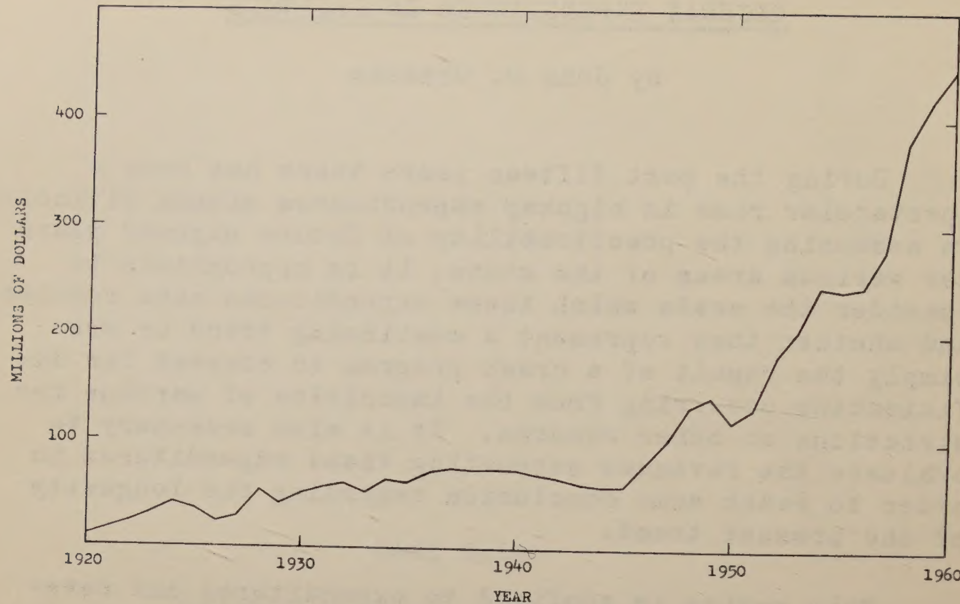

FIGURE 1 -- YEARLY EXPENDITURES FROM HIGHWAY FUNDS IN ILLINOIS, 1920-1960

The postponement of construction, because of wartime restrictions, almost certainly had only a delaying effect on the trend. When one considers that yearly expenditures have practically quadrupled in the past ten years, it is evident that a concomitant increase in vehicle registration and travel is the dominating factor in the rise. FIGURES 2 and 3 illustrate the accompanying trend in the use of the roads of the state and the rise in registrations. Expenditures have realistically followed the needs resulting from an increasing ownership coupled with the more intensive use of motor vehicles.

In the discussion above, total expenditures by the Illinois Division of Highways have been used. These do include administrative expenses and the motor fuel tax allotments to local governments. The trend for direct expenditures for maintenance and construction is more important in considering the financial ability of the state to undertake the fulfillment of a large scale transportation plan. FIGURE 4 shows the trend in the amounts expended by the Illinois Division of Highways for these functions. Once the exigencies of wartime were past, maintenance and construction expenditures also showed a rapid rise and exceeded 280 million dollars in 1960 or 64 per cent of the total.

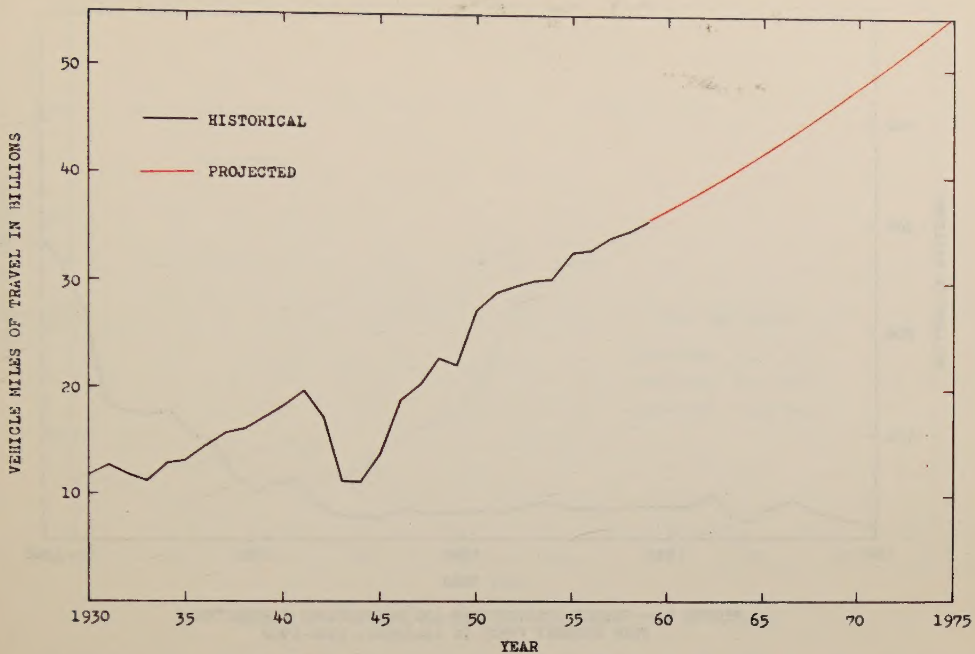

FIGURE 2 -- ANNUAL VEHICLE MILES OF TRAVEL IN ILLINOIS

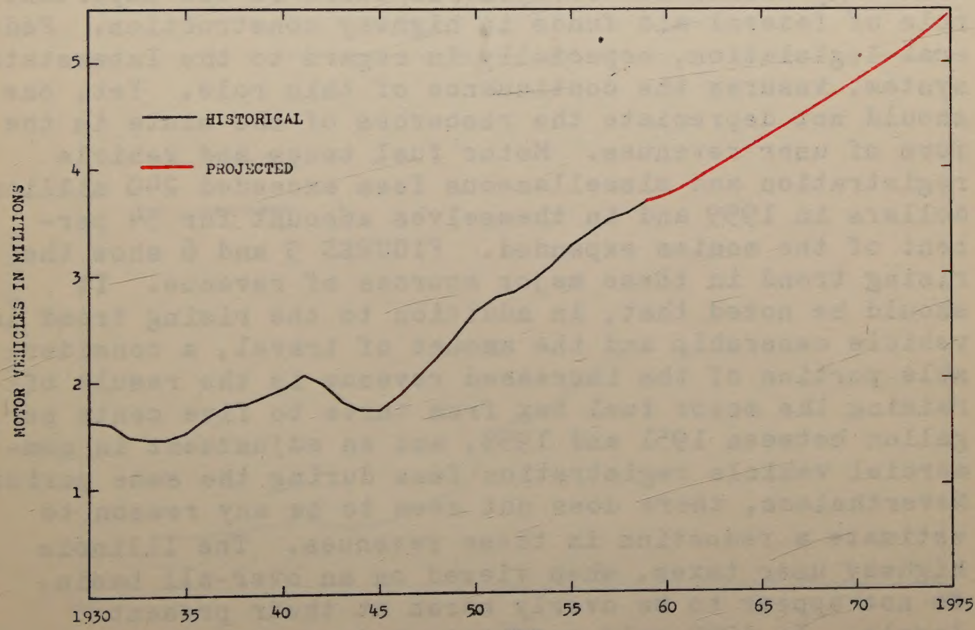

FIGURE 3 -- ANNUAL REGISTERED MOTOR VEHICLES IN ILLINOIS

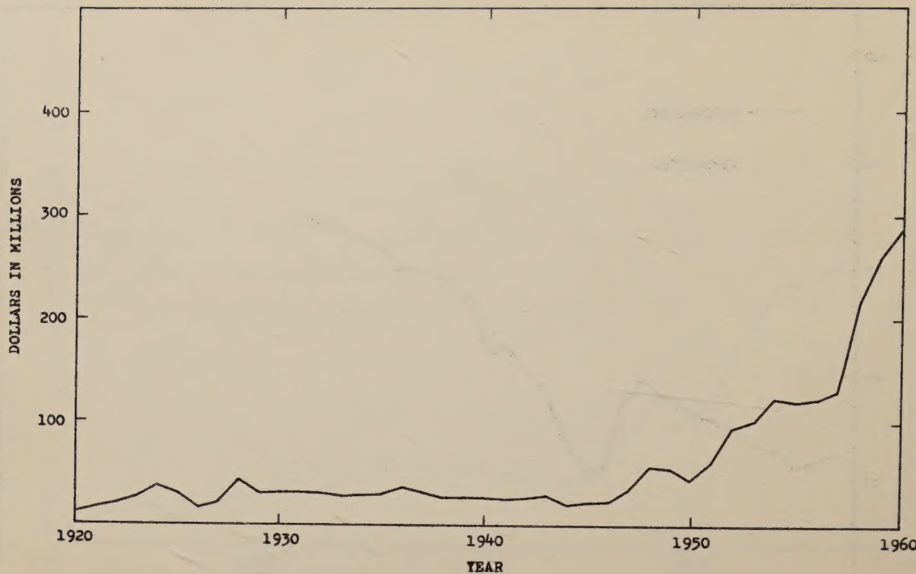

FIGURE 4 -- YEARLY CONSTRUCTION AND MAINTENANCE EXPENDITURES FROM HIGHWAY FUNDS IN ILLINOIS, 1920-1960

While it is plain that highway expenditures in Illinois have increased rapidly, an obvious consideration in determining whether the trend will be maintained in the future is to examine the revenues which support these expenditures. Everyone is aware of the important role of federal aid funds in highway construction. Federal legislation, especially in regard to the Interstate system, insures the continuance of this role. Yet, one should not depreciate the resources of the state in the form of user revenues. Motor fuel taxes and vehicle registration and miscellaneous fees exceeded 240 million dollars in 1959 and in themselves account for 54 percent of the monies expended. FIGURES 5 and 6 show the rising trend in these major sources of revenue. It should be noted that, in addition to the rising trend in vehicle ownership and the amount of travel, a considerable portion of the increased revenue is the result of raising the motor fuel tax from three to five cents per gallon between 1951 and 1953, and an adjustment in commercial vehicle registration fees during the same period. Nevertheless, there does not seem to be any reason to estimate a reduction in these revenues. The Illinois highway user taxes, when viewed on an over-all basis, do not appear to be overly harsh at their present levels. In 1960 only one state had a motor fuel tax

(Continued on page 16)

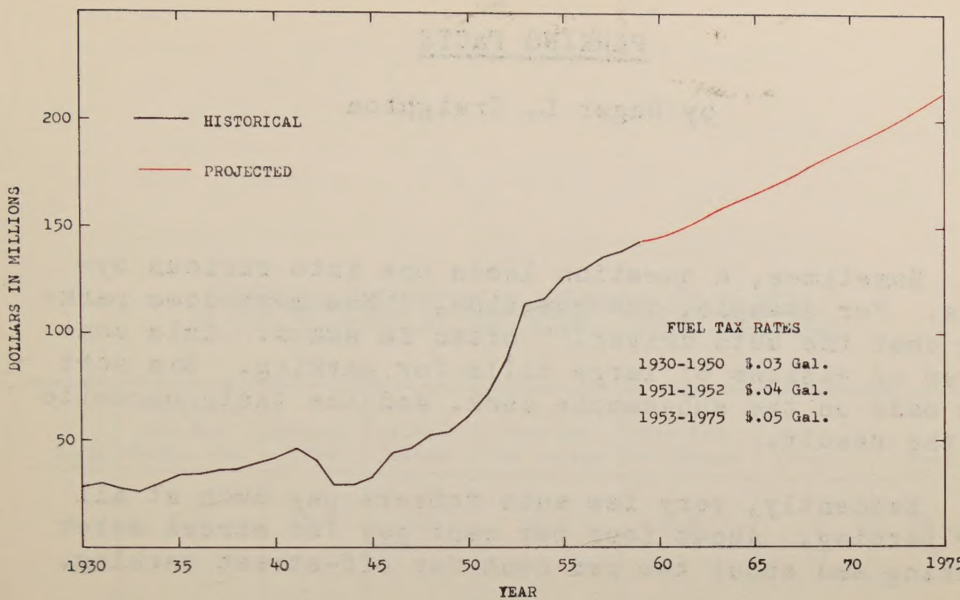

FIGURE 5 -- ANNUAL MOTOR FUEL TAX COLLECTIONS IN ILLINOIS

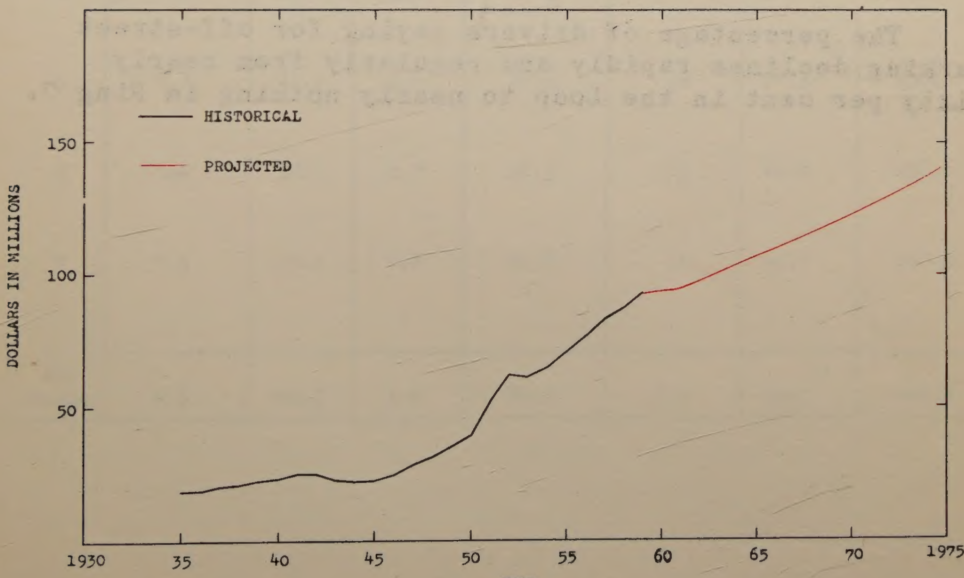

FIGURE 6 -- ANNUAL VEHICLE REGISTRATION RECEIPTS AND MISCELLANEOUS FEES IN ILLINOIS

PARKING FACTS

by Roger L. Creighton

Sometimes, a question leads one into curious by-ways. For example, the question, "How much does parking cost the auto driver?" often is asked. This conjures up visions of large bills for parking. So a sort was made on the sub-sample deck, and the table opposite is the result.

Evidently, very few auto drivers pay much at all for parking. About four per cent pay for street meter parking and about two per cent for off-street parking.

Nearly half of all drivers (46 per cent) park on the street. Much of this probably is a substitute for parking on residential property, since only 23 per cent park on residential property, and the number should be nearly forty per cent, which is the proportion of auto drivers going home. Note how the percentage of free street parking declines with increasing distance from Loop, while parking on residential property rises.

The percentage of drivers paying for off-street parking declines rapidly and regularly from nearly sixty per cent in the Loop to nearly nothing in Ring 7.

PERCENTAGE DISTRIBUTION OF AUTOMOBILE DRIVER TRIPS
BY TYPE OF PARKING AT DESTINATION, CHICAGO AREA, 1956

Ring	Cruised, Did Not Park, etc.	Street Free	Street Meter	Free Lot Or Garage	Paid Lot Or Garage	Res. Prop.	Total
0	5.8	15.6	3.0	16.4	58.8	.4	100.0
1	1.5	54.7	3.9	26.6	10.9	2.4	100.0
2	3.1	67.8	3.3	18.6	1.8	5.4	100.0
3	2.9	64.4	5.0	17.7	1.1	8.9	100.0
4	3.9	53.9	5.0	18.5	1.0	17.7	100.0
5	4.8	41.1	2.6	23.6	.6	27.3	100.0
6	6.4	32.1	2.7	18.5	.3	40.0	100.0
7	7.5	23.3	4.8	21.8	.1	42.5	100.0
All Rings	4.6	46.2	3.9	20.0	2.2	23.1	100.0

TRAVEL TIME MINIMIZATION, TRANSIT

(This is the first of a series on this subject)

by M. Schneider

In a recent memorandum, Roger Creighton has propounded a problem, or rather a family of problems, covering several levels of generality, concerning the arrangement of transit facilities. The memo was intended to excite skirmishing in the field, and this is merely a first sortie: I shall treat here only the most restricted form of the problem. Generalizations appear possible and may follow later, depending on how the battle goes and the morale of the troops.

Imagine a corridor, R miles long and w miles wide, with a transit line running down the middle. Certain trips occur at a uniform and immutable density everywhere within the corridor; these trips, and only these, use the transit line, come what may (unless the nearest transit station is farther than the terminus). They all have the same terminus at one end of the corridor (call it the CBD, just for spice); they all walk at the same speed to the nearest transit station (or to the CBD if it's closer). The single train runs at a constant speed between stations and experiences a constant delay at each station. Now then, how many stations should be spaced in what way to minimize the total time required for all trips to get downtown?

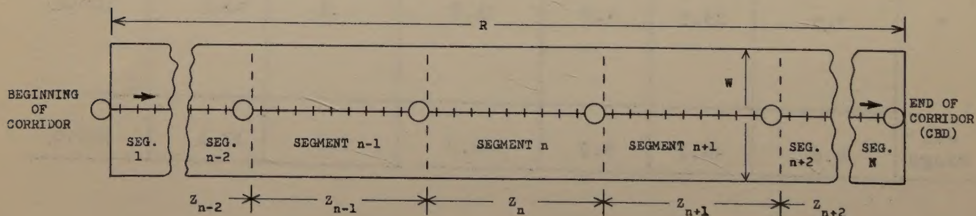

FIGURE 1 -- CORRIDOR PARTITIONING USED IN THE CALCULATION OF TRANSIT TRAVEL TIME MINIMIZATION

If the spacings between stations were to be held all the same, the problem would be trivial. As it is,

each spacing must be taken as an independent variable, though related to the others through the fixed length of the corridor. So, to begin with, the total travel time must be written as a function of any number of distinct spacings $Z_1, Z_2, \ldots Z_n$, with the condition

$$\Sigma Z_n = R \quad . \tag{1}$$

FIGURE 1 shows the partitioning that seems to allow the travel time contribution of each corridor segment to be stated in the simplest notation. Each segment is Z_n miles long and contains one station, at its right-hand border; the train runs from left to right. The number of passengers on the train as it enters the nth segment will be all those originating to the left of the nth segment plus those originating in segment n, but getting on at the station in segment n-1; remember that each passenger walks to the nearest station with no pride of segment at all. So the total time spent <u>on the train</u> in segment n is

$$pw\left(R_n + \frac{Z_n}{2}\right)\left(k + \frac{Z_n}{v}\right) \tag{2}$$

p is the density of transit trips (uniform throughout the corridor);

R_n is the distance from the beginning of the corridor to the beginning of segment n;

k is the delay introduced by stopping at the station (the same at all stations);

v is the speed of the train between stations (the same in all segments).

Stipulating that everyone must walk an L path, the average walking distance of a trip in segment n is

$$\frac{Z_n}{4} + \frac{w}{4}$$

and the total time spent walking in segment n is

$$pw\,\frac{Z_n}{4s}\left(Z_n + w\right) \quad , \tag{3}$$

where s is, of course, the walking speed used by everybody.

Putting (2) and (3) together, the total time spent traveling in segment n is

$$T_n = pw\left(R_n + \frac{Z_n}{2}\right)\left(k + \frac{Z_n}{v}\right) + pw\,\frac{Z_n}{4s}\left(Z_n + w\right) \quad , (4)$$

which may be rewritten

$$\frac{T_n}{pw} = k\,R_n + \frac{R_n}{v}Z_n + \frac{k}{2}Z_n + \frac{Z_n^2}{2v} + \frac{Z_n^2}{4s} + \frac{w}{4s}Z_n \quad . (5)$$

The total travel time in the corridor is simply the sum of these T_n's.

At this point the meticulous reader may notice that this partitioning does not correctly handle the first and last segments, and it serves him right. I therefore require that the first station be precisely at the beginning of the corridor, that the last station be the very point to which all travelers wish to go, and that all passengers arriving by train at the last station suffer the full station delay, k. These conditions could be removed at the cost of considerably more complicated notation, but with no real gain in generality.

Getting back to the total travel time:

$$\frac{T}{pw} = \frac{1}{pw}\Sigma T_n = k\Sigma R_n + \frac{1}{v}\Sigma R_n Z_n + \frac{k}{2}\Sigma Z_n$$

$$+ \frac{1}{2v}\Sigma Z_n^2 + \frac{1}{4s}\Sigma Z_n^2 + \frac{w}{4s}\Sigma Z_n \quad . (6)$$

The third and last terms in the right side of (6) obviously are determined by condition (1), and may be replaced by

$$R\left(\frac{k}{2} + \frac{w}{4s}\right) \quad . \qquad (6a)$$

Recognizing that the R_n's are

$$R_1 = 0,\ R_2 = Z_1,\ R_3 = Z_1 + Z_2,\ \ldots,$$

$$R_n = Z_1 + Z_2 + \ . \ . \ . + Z_{n-1} \quad , \tag{6b}$$

the second term becomes

$$\frac{1}{v}\,\Sigma R_n Z_n = \frac{1}{v}\left[Z_1Z_2 + Z_3\left(Z_1 + Z_2\right) + Z_4\left(Z_1 + Z_2 + Z_3\right) + \ . \ . \ . \right] \quad . \tag{6c}$$

The part in brackets looks suspiciously like one-half the cross products of the Z_n's, and is indeed just that. Now if the second and fourth terms in (6) are cunningly combined, they congenially collapse to

$$\frac{1}{2v}\left(\Sigma Z_n^2 + 2\Sigma R_n Z_n\right) = \frac{1}{2v}\left(\Sigma Z_n\right)^2 = \frac{R^2}{2v} \quad . \tag{6d}$$

Taking advantage of (6a) and (6d), equation (6) can be more conveniently stated

$$\frac{T}{pw} = \left(\frac{k}{2} + \frac{w}{4s}\right)R + \frac{R^2}{2v} + k\Sigma R_n + \frac{1}{4s}\,\Sigma Z_n^2 \quad . \tag{7}$$

Suppose, for the moment, that there is some fixed number of segments, N, and the problem is merely to determine the set of station spacings, $Z_1 \ . \ . \ . \ Z_N$, that minimizes the total travel time. This can be done by differentiating (7) with respect to each Z_n and setting each derivative equal to zero, subject to the constrain of equation (1). (There is one more constraint: each Z_n must be positive. Happily, it is never necessary to impose this troublesome condition directly, since the minimizing Z_n's all turn out to be positive anyway. There is nothing more natural here than to invoke a Lagrangian undetermined multiplier, giving as conditions for an extremum the set of N equations

$$\frac{\delta}{\delta Z_n}\left(T - \lambda \Sigma Z_n\right) = 0 \quad . \tag{8}$$

Looking back at (6b), the sum of the R_n's is clearly

$$\Sigma R_n = (N-1)Z_1 + (N-2)Z_2 + \ldots = \Sigma(N-n)Z_n \quad , \tag{9}$$

and the equations corresponding to (8) are

$$k(N-n) + \frac{Z_n}{2s} - \lambda = 0 \quad ; \tag{10}$$

so the minimizing Z_n's are

$$Z_n = 2s\lambda - 2sk(N-n) \tag{11}$$

(notice that the second derivatives are all positive, indicating minima). I might mention here that it is necessary to regard the number of segments as fixed only to permit the term by term differentiation of ΣR_n. Also, that the transformation of (6) into (7), introducing constant terms in R, is a simplification that alters no result; working with equation (6) would be rather more tedious, but would change nothing except the value of the undetermined multiplier. And who cares about the value of an undetermined multiplier? In the same way, the pw that I have casually shifted to the left side of all equations may be ignored.

Inspection of equation (11) leads to a simple recursive expression:

$$Z_n = Z_{n-1} + 2sk \quad . \tag{12}$$

In words, every spacing should be greater than the preceding one by twice the distance that can be walked in one station delay time. This may also be written

$$Z_n = Z_1 + (n-1)2sk \quad . \tag{13}$$

Summing the Z_n's and inserting in equation (1) gives

$$NZ_1 + N(N-1)sk = R \quad , \tag{14}$$

or

$$Z_1 = \frac{R}{N} - (N-1)sk \quad , \tag{15}$$

thus determining all Z_n's as functions of N, the number of segments.

These Z_n's - the least travel time spacings for any given number of segments - can now be inserted in equation (7), giving the least total time for any N. This can then be differentiated with respect to N and set equal to zero, determining the number of optimally sized segments that minimizes total time. The whole thing is a thoroughly messy process and by now I imagine the reader will be glad to waive the detailed manipulations. If not, he is welcome to go through them for himself, as long as he doesn't crow over my mistakes. The result, at any rate, is this equation:

$$\frac{k^2 s}{2}\left(N^2 - \frac{1}{3}\right) + \frac{kR}{2} - \frac{R^2}{sN^2} = 0 \quad . \tag{16}$$

Dismissing the 1/3 in the first term as entirely negligible, this can easily be put in the form of a fourth degree equation with, thank heaven, the odd degrees missing. The only real and positive root is

$$N = \sqrt{\frac{R}{ks}} \quad . \tag{17}$$

N here is not generally an integer, of course, but one of the nearest bounding integers will clearly be the minimizing whole number of segments. That the Z_n's are all positive may be seen by inserting (17) into (15).

To recapitulate: the set of station spacings that minimizes total travel time is given by

$$Z_n = \frac{R}{N} - (N - 1)sk + (n - 1)2sk \tag{18}$$

where N is the number of inter-station spacings, that is, one less than the number of stations, and

$$N \sim \sqrt{\frac{R}{ks}} \quad . \tag{19}$$

For example, if the station delay (k) is 1/20 of an hour, walking speed (s) 2 1/2 miles per hour, and the corridor 30 miles long (R), then there should be 15 spacings: the first two stations should be .25 miles apart, the third and second stations should be .50 miles apart, and so on.

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HIGHWAY EXPENDITURES (Continued from page 6)

rate lower than the Illinois charge of five cents per gallon. Further, in 1958 Illinois ranked thirty-fifth among the forty-eight states in revenue per registered vehicle from these sources.*

Thus, while there is a possibility of adjustment within the present revenue structure, it is not likely that their amounts will decrease. The predicted rise in vehicle ownership, and the continued increase in the total vehicle miles of travel on Illinois highways, will certainly work toward maintaining highway user revenues. Projected revenue estimates prepared by the Division of Highways are shown in the pertinent charts. They indicate that if the present trend is maintained, highway user revenues will exceed 360 million dollars. Their combination with the present long term federal highway program appears to insure that expenditures of the Illinois Division of Highways will continue at a high level.

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* Calculation based on 'Highway Statistics 1958," published by U.S. Bureau of Public Roads. Tables G-1, MV-1, MV-2.